Tevatron Collider Experiment Task Force Report

December 30, 2005

Executive Summary

This is the December 2005 report of the Tevatron Collider Task Force. The task force was established by Fermilab Director Pier Oddone to evaluate the personnel resources needed to operate CDF and DØ through 2009 and to perform the physics analysis of the data in a timely fashion; to compare these needs to estimates of the personnel resources available from the two collaborations and Fermilab; to identify shortfalls or gaps; and to suggest remedies.

The task force has analyzed the resources needed to operate the detectors and support the needs of data processing and computing algorithms. We use the word "service" to describe the sum of these efforts. These three tasks include all activities required to produce calibrated and fully reconstructed "physics quality" datasets and Monte Carlo samples, including all of the basic tools needed to perform the physics analyses, such as identification of leptons, b-tagging, jet energy scale calibration, etc.

Defining the effort needed for the analysis of the extremely broad, world class, physics program is more difficult. At some point it may be necessary to limit the scope of the analyses due to limited available effort. For our first labor analysis we defined a "core" physics program of ten topics. It is neither desirable nor achievable to restrict the physics analysis scope, so this core effort estimate is a minimum personnel requirement. The core program places complete demands on the performance of the detectors, triggers, reconstruction programs, higher level algorithms, calibrations, and Monte Carlo programs, and provides access to the entire spectrum of final states of interest at the Tevatron. Therefore the service work necessary to deliver the core physics is sufficient to support a much broader physics program. To obtain a second estimate of the available analysis effort, we have used the service results and assumed that physicists will devote at most 50% of their time to service, leaving 50% for analysis.

This committee has also developed estimates of the resources available to carry out the service and analysis efforts. For university physicists, service estimates are based on commitments captured in Memoranda of Understanding (MOUs) between the collaborations and the Principal Investigators. Fermilab's resource contributions were developed by the PPD and CD in concert with each experiment's operations teams.

We have concentrated on analyzing the needs and availabilities for the year 2007. For obvious reasons, many institutes can not make firm commitments to the Tevatron experiments beyond 2007. Beyond the FTE sums required to fulfill the program, the Task Force has also attempted a detailed analysis of the expertise available through 2007. A comparison of the specific commitments listed in the MOUs and the requirements of the core program has identified a number of areas requiring additional effort. These shortfalls are not numerous and can be accommodated through laboratory expertise, redirection of collaboration effort, and sustained university support.

The situation is less certain in the years 2008-2009, and it is more difficult to estimate the available effort in those years. Estimates for those years used current FTEs available and scaled them using the recently conducted HEPAP survey. Because the Tevatron luminosity will continue to increase, and some algorithm development will still be taking place, service labor requirements will not reach their lowest levels until the end of 2007. We have estimated the additional reductions in the steady state, and used them to estimate the requirements for 2008 and 2009.

The main findings are:

1) The number of physicist FTEs available to each experiment is expected to decline from 2005 levels by approximately 27% by 2007 and 56% by 2009. We find that the HEPAP personnel survey and the MOU surveys carried out by the experiments agree well in 2005 and 2007. For CDF, the current estimates for operations agree well with HEPAP estimates but the current best estimates for physics analysis are lower due to a difference in the scope of the physics program that is delivered. For DØ, it is just the reverse. The effort needed to deliver the operational program is substantially lower than those reported to the HEPAP survey whereas that devoted to physics analysis is consistent with HEPAP.
2) In 2007 we find an approximate balance between needs and availability, even when a physics program broader than the core program is considered. The experiments have enough personnel to operate. The greater degree of development still expected in 2007 for DØ relative to CDF is partially compensated by a somewhat larger expected number of FTEs. However in both experiments there are a limited number of areas in which specific expertise is not yet identified.

3) There are a number of areas where Fermilab PPD and CD effort should be used to increase productivity and efficiency of the experiments. They will require modest additional resources from the laboratory for staff and visitor support. The Computing and Particle Physics Divisions have presented their currently expected budgets and staffing levels; they should be able to at least maintain support at their current levels.
4) For 2009, the projected resource needs and availability show either a balance, or a deficit at the 10-20% level, for each experiment, depending on the analysis methodology. This does not include remedies proposed in Section 7. In the opinion of the task force those remedies are necessary, but will need to be augmented in 2008-2009 to ensure successful completion of the Tevatron program.

In the report, the task force makes several recommendations to the collaborations, the Particle Physics Division and Computing Division in the following broad categories:

1) Decreasing the overall numbers of physicists required to operate and maintain the detectors including: transferring more of the expert responsibilities to permanent laboratory staff; improving shift efficiency by having longer tours of duty to reduce learning curves and overall need; automating the monitoring and detection of problems; eliminating problems that require protracted attention; improving documentation and trouble-shooting procedures; and, in the computing area, adopting common solutions wherever possible, moving key infrastructure into centrally supported services, and leveraging the large and increasing effort devoted to LHC grid technologies.
2) Broadening the personnel pool that contributes to operations and maintenance: Steps include encouraging the involvement of additional institutions and providing support for people who want to participate by expanding the guest and visitor programs.
3) Ensuring that available personnel are properly targeted to essential operational, software, and computing projects. Similarly experiment management must also ensure that key analyses are properly staffed.

The recommendations to the Fermilab Director that he can undertake to support Run II within the laboratory are:

1) Require the divisions to update the laboratory staff profile needed to fulfill Fermilab responsibilities to complete the Tevatron program
2) Communicate to Fermilab staff scientists engaged in the Tevatron collider program the laboratory staff plan for the Tevatron and LHC, and plans for future CMS membership opportunities.
3) Encourage the experiments and divisions to continue developing efficiencies that reduce the effective labor required to operate the Run II programs.
4) Continue to promote the Tevatron program to incoming Research Associates, and, starting in FY06, increase the number of CDF and DØ RA positions by two each.
5) Periodically review with the collaboration spokespeople the degree to which institutional MOU commitments are honored.
6) Provide strong support for the LHC Physics Center (LPC) at Fermilab and for Fermilab's US CMS hosting activities. In addition, we recommend expansion of the LPC to include limited support for members of ATLAS working on Run II.
7) Pursue discussions with the International Finance Committee (IFC) from both collaborations to secure and understand their commitments to the program through 2009.

We make some recommendations that require additional resources. These are issues for the Director to explore with the funding agencies.

1) Increase visitor budgets for outside personnel by approximately a factor of two.
2) In concert with the collaboration spokespeople, conduct negotiations with NSF, DOE, and foreign funding sources aimed at retaining or enhancing support for University resources in the areas of greatest risk.
3) Discuss jointly with LHC and Tevatron experimental leadership the difficulties faced by groups and individuals active in both programs. These groups frequently find it difficult to fully contribute to two programs through the Tevatron-LHC transition period.
4) Explore the possibility of contributions from the funding agencies for the creation of **Tevatron Fellowships** to support named university students (5-10 per experiment).
5) Similarly, explore the possibility of support from the funding agencies for the creation of **Hadron Collider Fellowships** to support post-docs (3-6 per experiment) resident at Fermilab. The three or four-year fellowships might initially focus on the Tevatron program with a transition to LHC occurring late in the second or early in the third year of the Fellowship.

1 INTRODUCTION

1.1 MOTIVATION, CHARGE, AND COMMITTEE MEMBERSHIP

This is the report of the "Collider Experiment Task Force." The task force was formed by Fermilab Director Pier Oddone. In his charge, he wrote "Over the course of the past year, there has been a steadily growing concern about the scientific and technical effort dedicated to the Tevatron Collider experiments." This situation is expected to become serious as physicists leave to participate in the Large Hadron Collider at CERN, scheduled to begin operations in 2007, and as Fermilab resources move onto other laboratory programs. He charged the task force to "review what is known about the scientific and technical needs for completing the Tevatron program through 2009" and to compare the needs with the available resources. In the case that the task force found that a gap existed, he charged it to "move to develop a suite of potential remedies." The task force was to start by concentrating on the period through 2007 and to deliver its first report by September 7, 2005.

Members were drawn from the leadership of CDF, DØ, the Fermilab Computing Division (CD), and the Fermilab Particle Physics Division (PPD). Professor Raymond Brock of Michigan State University, who, along with Dr. James Whitmore of the NSF, co-chaired a physicist resource study commissioned by HEPAP, was asked to participate. Both CDF and DØ have strong international collaborators whose involvement is crucial to the operation of the experiments and the analysis of the data. In order to make sure that the committee received input from the program's international participants, a senior foreign collaborator from each experiment was included on the committee. The full charge and committee membership appears in Appendix 1.

1.2 WORKING ASSUMPTIONS AND CAVEATS

The task force assumed that the Tevatron luminosity would follow the plan that Fermilab presented to the US DOE in the spring of 2005. This indicates the timeframe at which the instantaneous luminosity is projected to level off and accordingly defines the time that triggers will stabilize. The luminosity profile will also determine how much data will be available for processing and when and how much radiation damage may occur to the detectors. Based on this, both detectors have concluded that radiation damage is unlikely to seriously affect overall performance once the final round of upgrades is completed.

Presently, the two experiments are operating at very high efficiency. We used the effort required to achieve this as the baseline for projections. We assumed that this level is acceptable and did not try to argue for additional resources to improve efficiency. In establishing this baseline, we subtracted certain upgrade activities, mainly for DØ, from the existing inventory of resources. We discussed certain efficiencies that have been identified and that the experiments now plan to implement, but did not take credit for them in the accounting of operations needs.

Data processing is also efficient. We use the effort required to operate efficiently as the baseline for projections. The support has recently been rearranged by a consolidation of the CDF and DØ support groups in the Computing Division into a single group and by adoption of common technologies. This is expected to reduce the total number of people required to support both efforts. Some additional improvements are expected over the next few years.

The number and characteristics of physics personnel required to execute the physics program is difficult to estimate. The physics program is broad and could easily support more analysis efforts than are currently being carried out. However, in order to provide a minimum estimate, the committee defined a "core physics program" that contains very high priority analyses. This is, of course, a matter of scientific judgment and taste but there was broad agreement on the topics. The physics needs were then based on an extrapolation of the current Run II effort for the core program analysis. It should, however, be understood that additional effort above that specified would result in the completion of additional physics analyses. Many of these are significant analyses and should be carried out. Historically, many lines of research topics that are believed to offer no surprises produce exciting, new, and significant results.

Resources are made available to each division based on the laboratory planning process. Both the Particle Physics Division and the Computing Division have guidance on their personnel and M&S budgets. It is assumed that Run II will continue to be among the highest priority projects of the laboratory.

Physics personnel on CDF and DØ are from university groups in the US and abroad, from Fermilab, and from other national laboratories in the US and abroad. The participation of these physicists is voluntary. Many of the physicists are beginning involvement in other efforts, especially experiments at the LHC. In order to determine the level of participation of external collaborators, CDF and DØ have been negotiating Memoranda of Understanding with all collaborating institutions. This process is not yet complete and extends for the most part only through the end of FY06 for CDF and through FY07 for DØ. For that reason, resource estimates are the best for that period. In addition, HEPAP commissioned a working group to study physicist resource availability over the period from 2005 to 2010. This study was very thorough and eventually received information from a very large fraction of all US HEP groups. However, it did not encompass foreign collaborators.

Much of the task force work is summarized in spreadsheets describing the needs for various tasks and the resources available for them. CDF and DØ are organized somewhat differently. Their detectors have different strengths. In many cases, tasks with similar names actually describe somewhat different activities. We have tried to develop a common set of task definitions and summarize activities for both experiments using these common definitions. Where this has not been possible, we have tried to make that clear.

Understanding and interpreting the data in the spreadsheets has been a major focus of our task force's efforts. For example, in High Energy Physics, it is not easy to "dictate" the physics that people do. University groups are supported independently through the DOE and NSF base programs, or if non-US through corresponding funding sources in their home countries. Each group expects, and is expected by its funding agencies, to exercise personal judgment as to what physics analyses members pursue. A second issue is that there are now expectations and traditions in each collaboration for the proper ratio of service work to physics analysis. The numbers in the table may or may not support those expectations. Finally, the numbers do not reflect the experience or competence of the people actually available to do the work. While much of the actual analysis work is carried out by students and research associates, seasoned mentors may serve as analysis group "conveners" who carry the experience gained in one generation of the analysis to the next.

1.3 WORKING GROUP ORGANIZATION

In order to carry out its work, the task force formed four subgroups. Subgroup 1 worked on identifying the available resources. Subgroup 2, 3, and 4 worked on identifying the needs for experiment/detector operations, computing support at the experiment and for data processing, and the execution of the physics program, and emphasizing physics analysis, respectively. Subgroup 1 organized the discussion of the analysis of resource shortfalls or "gaps", to which all members of the committee contributed. All subgroups contributed to the discussion of remedies for identified gaps.

The remainder of this report is organized as follows: Section 2 enumerates the personnel required to operate and maintain the detectors; Section 3 lists the personnel needed to process the data up to physics analysis; Section 4 describes the resources required to carry out the "core" physics analysis; Section 5 lists the resources that are expected to be available from the CDF and DØ collaborations. In section 6, the "needs" and "resources" are compared and any gaps in coverage are identified. Section 7 discusses various remedies to close the gaps. Section 8 collects and summarizes the main findings and recommendations.

2 DETECTOR OPERATIONS

Efficient round the clock operation of complex hadron collider detectors requires a fully staffed control room with crews of operators (shifters) backed up by on-call experts. The control rooms are currently populated with ~5 shifters, each having specific areas of responsibility. Physicists who serve as shifters frequently devote only a small fraction of their time to shifts in the control room, and have other responsibilities that occupy the majority of their time. Consequently, such shifters are not generally expected to be detector experts. Shifters must have sufficient training and knowledge to perform the routine tasks, and recognize and respond appropriately to unusual situations, such as failures of various detector elements. When a shifter detects a situation that is beyond his or her skill level, appropriate on-call experts are contacted. Maintenance and operation of the various detector elements also requires the attention of various additional experts and support staff. The diverse, complex nature of the detectors requires a large number of experts. Many of those experts must devote only a fraction of their time to the detector once it is in steady state operation. However, since the expertise must be accessible around the clock, it is essential to have back-ups to the individual experts to maintain efficient operations.

Estimates of the numbers of experts and infrastructure support personnel required to operate the various subsystems of the CDF and DØ detectors and the fraction of their time devoted to those activities are presented in Table 1. In current steady state operation, the total number of full time equivalents (FTE) necessary to operate and maintain each detector (excluding the shifters) is estimated at about 60 FTEs, spread over about 130 people. Roughly 20% of those people are technical staff such as engineers, computing professionals, technicians, administrative assistants, and building managers. These numbers account primarily for personnel working in the detector complexes, and do not include the more general infrastructure support provided by the laboratory.

Approximately five full time equivalents are required to staff each shift slot that must be filled round the clock. These shifts, with the exception of the operations shifter, who is a technician, are generally filled from a large pool of physicists (with duty factors varying depending upon the type of shift responsibilities). In the current mode of operation, approximately 330 people per collaboration are required to fill these shifts, amounting to a full time equivalent of about 25 people.

In order to understand possible savings in shift personnel resources, it is helpful to outline current usage of those resources. To avoid duplication, we discuss here only the DØ model. Infrastructure such as cryogenics and environmental controls are monitored and maintained by the Operations Shifter. The Captain has responsibility for coordinating activities, including communication with the accelerator control room, and is also responsible for monitoring the results of high-level event reconstruction programs and trigger rate monitoring tools. The Data Acquisition Shifter is responsible for operating the data acquisition system, starting and stopping runs, and ensuring data is properly logged. There are three shifters responsible for monitoring the performance of the various detector elements, responding to detector failures, and performing the calibrations of the detectors between stores. These shifters are referred to as the SMT, CFT and CALMUO Shifters because they are primarily responsible for monitoring the Silicon Microstrip Tracker, the Central Fiber Tracker, and together the Calorimeter and Muon systems. The SMT has ~800,000 channels of readout, the CFT system has ~100,000 channels, and the Calorimeter has ~50,000 channels. The muon system is composed of ~5,000 scintillation counters and ~55,000 drift cells. In addition to this crew of shifters, there is another slot filled two to three shifts a day to (primarily) monitor offline event staging and processing.

In the past, the DØ calorimeter and muon systems were each monitored by independent shifters, but those responsibilities have been merged, eliminating the need for a shifter, thus saving about five full time equivalents. Until a few months ago, the monitoring of the online high-level event reconstruction results and trigger rates were performed by another independent shifter, but those responsibilities have since been turned over to the Captain.

Over the past several years, the operating efficiency of the detector has been improved through experience, training, improved documentation, addressing troublesome elements, and enhanced monitoring. Many of the key voltages, currents, temperatures, and other parameters of the experiment are monitored by computers, and an alarm system brings to the attention of the shifters parameters that have wandered out-of-range. Depending upon the severity of the situation, data acquisition may be automatically paused, and an audible alarm issued. The data acquisition system will also automatically send out an initialization signal upon detection of conditions that have caused system confusion. Such automation significantly improves detection efficiency and response time to problems. Individual detector groups have identified weaknesses in their detector implementation, and replaced those individual elements. Firmware has been upgraded to make the detectors more robust, data more reliable, and allow recovery of readout channels. Power supplies and power supply distribution systems have been upgraded to address sensitivity to radiation and operating conditions. Several of the subsystems have significantly enhanced the online monitoring programs so that the data quality assessments are either automated or much more straightforward for the shifter to evaluate. Some data monitoring programs are also capable of raising alarms when unusual conditions are detected. We continue to monitor and track the causes of detector inefficiencies, and attempt to address root causes of data losses. Since the beginning of the run, the DØ detector has averaged 84.4% efficiency, and ~30% of that loss is attributable to the readout deadtime.

	CDF Operations Personnel Estimates		**DØ Operations Personnel Estimates**	
Subgroup	**# people**	**Total FTE per subgroup**	**# people**	**Total FTE per subgroup**
Management	5	2.50	5	3.0
Alarms and Controls	1	1.00	3	2.00
Online and Data Acquisition	8	3.50	4	1.60
Data Quality Monitoring	8	1.10	14	4.00
Silicon Detectors	17	7.25	8	3.00
Outer Tracker	5	2.30	8	2.90
Calorimeters	14	2.60	10	3.60
Muons	13	3.00	17	8.90
Time of Flight	2	0.50	0	0.00
Luminosity Detector	2	1.00	4	1.85
Trigger	5	2.50	4	0.70
Level 1 Trigger	7	2.25	11	4.00
Level 2 Trigger	8	1.30	10	2.10
Event Builder/ Level 3 Trigger	7	2.25	5	0.95
Infrastructure Support (technical)	21	20.40	32	26.02
Infrastructure Support (scientist)	0	0	3.0	0.6
Total Scientific Effort	102	33.05	106	39.01
Technical Effort	21	20.40	32	26.02
Shift Effort	312	22.41	366	28.42
Total (including Shifts Category)	435	75.86	504	93.45

Table 1: Resources required for detector operations and maintenance. Note that the “Operations Shifter” is listed under “Infrastructure Support” for both CDF and DØ.

The spreadsheet obscures two issues. Firstly, many of today’s “experts” worked on the construction, installation, and commissioning of these systems. If these key people leave the experiment adequately knowledgeable replacements will be difficult to identify. A long learning curve might be necessary for new personnel. Secondly, it is hard to assess the demands for operations and expert personnel. If the detectors age gracefully, operations needs and the need for expertise should decline as problems are cataloged, remedial actions are documented, and in some cases fixes implemented. However, if some detectors age badly, the situation could be reversed.

If faced with operation of the detector with diminishing staff or increasingly frequent failures due to aging, very undesirable (and potentially costly) alternatives are the reduction of the scope of the detector or the reduction of the level of support for the detector. If the team of experts is further reduced, we will likely encounter occasions where the response time to failures suffers.

3 COMPUTING SUPPORT AND DATA PROCESSING

Offline computing consists of a broad array of services, hardware, and software systems required to carry out the timely reconstruction and analysis of data. Some of these systems and services, such as data handling, networking, and system administration, are common to both experiments. Support for such "central services" comes primarily from Computing Division resources. Effort provided by the collaborations typically focuses on experiment-specific support roles, such as coordination of data processing tasks.

Position/functionality	**Now/development**				**Steady State**		
	CDF FTE	DØ FTE	Shared FTE		CDF FTE	DØ FTE	Shared FTE
Management	7.0	4.3			5.4	4.3	
Operations							
Central Farm	2.2	0.0			1.5	0.0	
MC Production	4.0	1.0			3.0	0.5	
Reprocessing	1.0	1.8			0.0	1.8	
Sys. Administration							
Institutional Systems	2.0	3.0			2.0	3.0	
Data Bases	2.0	2.5			2.0	1.2	
Builds and Code Support	0.0	1.0			0.0	0.5	
Data Handling	2.75	1.0			1.65	0.8	
Distributed Computing (CAF/SAMGrid Offsite Centers)	4.5	16.0			4.5	11.5	
Job Control/Tools	0.2	1.5			0.2	1.5	
Sub-total	25.65	32.1			20.25	25.1	
CD Central contribution	16.35	13.9	8.0		17.35	12.9	6.0
Total	42.0	46.0	8.0		37.6	38.0	6.0

Table 2: Resources needed for support of offline computing and data processing. Note the sub-total line gives the resources supplied from the collaboration scientific staff. The CD central contribution is comprised of computing professionals mostly employed by Fermilab CD.

Table 2 lists by task category and by the experiment the computing resource requirements for the Run II experiments now and in a long-term “steady state" condition. Contributions to the central services are divided by experiment only when the tasks are experiment-specific. The "shared" column refers to central services for which the Run II experiments are the primary stakeholder, and includes all effort that is not experiment-specific. We include in the table estimates for the effort provided in direct support of the experiments, but not that for more general services or infrastructure provided by the Computing Division.

To estimate the "steady-state" needs, we reduce the current workforce devoted to development projects to a level more appropriate for product maintenance. We also assume that various operational and management roles will allow modest reductions in effort with time as more routine tasks are automated, recurring problems are fixed, and systems in general become more stable. This entire exercise requires care, however, in order to avoid removing personnel from computing projects that become increasingly complex with time. Data handling services, for instance, will face increasing data volumes, data rates, and transaction rates as the experiments proceed changes which will likely expose scaling issues in the underlying products. Some development effort must remain to address such problems.

We estimate that a total of about 96 FTEs are currently required for offline computing, including about 42 for CDF, 46 for DØ and 8 in common to both via central services. Of the experiment-specific support, the Computing Division supplies technical staff amounting to about 16 FTEs for CDF and 14 FTEs for DØ, all in support of central services. The collaborations provide the balance of the experiment-specific effort via MOU agreements with various institutions. Within the contributions from CDF, project management (7 FTEs) and distributed computing tasks (4.5 FTEs) require the most FTEs; the largest DØ tasks are again project management (4.3 FTEs) and distributed computing (16 FTEs). The "shared" category includes approximately equal effort devoted to management, application support and data handling. The difference in the “distributed computing” number reflects the different emphasis currently given to distributed GRID activities by the two experiments.

In steady-state operation, the total computing effort drops by about 16% to an estimated 81 FTEs, of which 6 FTEs are in common-support of central services. The level of experiment-specific effort for central services from the Computing Division is again about equal to that from the experiments.

This subgroup examined the data underlying the spreadsheets to look for issues and vulnerabilities that could impact the overall view of resource availability for the remainder of Run II. A number of effects introduce risk into the computing plans for the experiments or the resources that will be available to complete a specified task in the future. These risks need to be taken into account in evaluating the balance between overall needs and resources that is presented below in Section 6.

Both experiments, for example, will require access to computing resources in shared grid pools, either to have continued access at sites already in use or to expand to sites beyond the institutions within the collaboration. The committee identifies the following issues as areas of risk in implementing this grid-based strategy.

- Deployment of SAM grid and grid technologies: While DØ has a long-standing commitment to grid-based computing, the deployment of the required products remains a highly specialized and labor intensive activity. Achieving such deployments in a personnel effective way will become increasingly important as the need for grid-based services grows.

- SAM grid interoperability: The core feature of grid technologies is interoperability between grid sites. The Computing Division has invested effort into making SAM grid interoperable with existing LHC grid infrastructure. Completion of this project will be required for the long-term success of DØ computing.

- Development of grid-based analysis model: DØ has successfully deployed a grid-based data production system. Both CDF and DØ have exploited significant remote CPU resources for analysis. Although both utilize SAM for distributed data handling, neither uses an integrated grid-based solution. Continued and expanded use of distributed computing for analysis will require the development of a viable grid-based analysis model.

A second set of issues is staffing-related. It may be difficult, for instance, to find qualified experts within the limited pool of the reduced collaboration to lead a particular project, or to move people within the collaboration to meet specific needs. In other cases, the collaborations rely on single, highly-skilled individuals to support complex or critical systems, an arrangement that is sustainable neither for the experiment nor the individual. If one of those individuals were to be among those leaving for another project, there would be a serious problem. The following issues have been identified.

- Desktop, Trigger farms, and Database support: The collaborations now support several key computing systems at either the hardware or service software levels. Notable examples include the support of important database applications for both experiments and the Level 3 trigger farm hardware and service-level software, both of which are required for data taking; and the DØ desktop systems, which are one of the primary analysis platforms for the experiment. Maintaining support for these systems with collaboration effort may become increasingly difficult as the resources available to the collaborations decline.

- DØ online systems/DØ offline code management: Each of these critical tasks is carried out by only one person. Though all requirements are currently met, the lack of depth and backup in these two areas represents a risk to sustained operations.

- Scientific positions within the Computing Division: Attracting highly qualified physicists to staff open Research Associate positions within the Computing Division has been difficult. Part of this difficultly is believed to stem from a perception that computing jobs are not in the long-term interests of those seeking later faculty appointments. Filling these with qualified candidates is critical for some computing projects.

4 PHYSICS PROGRAM NEEDS

4.1 WORKING GROUP PROCEDURE

The Working Group has concentrated on the resources needed in FY 2007 and 2009. The mode of operation has been to collect detailed input from managers of the current analyses and of the required algorithm development. Individuals with major involvement in the analyses listed in our core physics topics have also been contacted. The numbers obtained have been adjusted for consistency and to avoid double counting. The task force met frequently to discuss the results of this "bottom-up" estimate and understand the differences between CDF and DØ.

4.2 CORE PHYSICS TOPICS

The range of physics topics currently addressed at the Tevatron Collider is extremely large and varied. In a scenario of reduced resources, however, the experiments may be forced to narrow their focus. We have therefore concentrated on defining and understanding the resource requirements needed to successfully produce a smaller "core" set of results. We have based our predictions on this reduced list of physics topics. In our opinion the core amply justifies continued running of the Tevatron until the end of FY 2009, as currently foreseen in the Fermilab long-range schedule. This analysis set should be viewed only as an example that can be used to set the scale of the minimum required effort. As the physics analyses develop, the set will be adjusted based on what is learned from the data. It is also implicitly assumed that more topics can and will be pursued if more resources are available relative to the resources strictly needed to fulfill this "core" list.

These Core Physics topics are:

- Measurement of Δm_S or limit on B_S mixing;
- Measurement of $\Delta\Gamma_S/\Gamma_S$;
- Limit on the branching ratio of the process $B_S \rightarrow \mu^+\mu^-$;
- High precision measurement of the W boson mass;
- High precision measurement of the top quark mass;
- Measurement of single top production cross-section;
- Search for the Higgs boson both in the Standard Model and SUSY scenarios;
- Searches for SUSY in the "golden" mode Gaugino-neutralino with tri-leptons;
- Searches for SUSY in the "golden" mode Squark-gluino with multijets plus missing transverse energy;
- Searches for high mass resonances in the e^+e^-, $\mu^+\mu^-$, $\gamma\gamma$ and jet-jet invariant mass spectra (sensitive to Large Extra Dimensions, Z' and other processes not present in the Standard Model); and
- In support of these ten topics, we also consider resources required for analysis coordination:
    - Management of physics groups
    - Committees to combine Tevatron data analysis
    - "Godparents" and Editorial Boards for publication approval

4.3 ALGORITHMS

The core physics topics require continued development and maintenance of many types of algorithms, in particular our reconstruction and simulation software, trigger studies to adjust the trigger for the increasing instantaneous luminosity through FY07, and high level data handling such as skimming of data and preparation of common data samples. In practice the core physics topics require algorithms covering the entire detector and software systems, so that non-core physics topics would need no further algorithm work. A list of the algorithms categories follows:

- Tracking
- Muon reconstruction
- Calorimeter calibration
- Electron and photon reconstruction
- Tau lepton reconstruction
- Jet reconstruction and calibration
- b-tagging
- Trigger development
- Detector simulation
- Luminosity measurement and bookkeeping
- High level data handling

4.4 RESULTS

The personnel required by CDF and DØ to execute a core physics program are summarized in Table 3. The numbers in this spreadsheet are vastly different from that of the HEPAP survey, because they are based on a completely revised and limited physics program. In the HEPAP survey, CDF estimated that ~250 FTEs were needed to maintain an identical physics program between FY04 and FY07. The physics analyses used to generate the estimates listed in Table 3 are much more focused -- restricting the collaboration goals to ten core physics analyses that are scientifically important in their own right and also represent the best capabilities of the Tevatron program. The choice of this core set of analyses is recognition by the collaborations that the available effort for physics analysis as well as operations will most likely shrink in the later years of Run II and that some prioritization of physics will be necessary.

Approximately 80 FTEs are estimated necessary to complete the core set of analyses in 2007 by CDF. To evaluate the accuracy of this estimate we looked at the composition of two of the three largest physics groups on CDF, the Top group and the Exotics group. In both groups we examined the effects of a reduction of the number of analyses currently in progress, identified possible areas for efficiency improvements, and performed cross checks to ensure consistency and identification of all remaining effort needed in the core topics. In the CDF Exotics group, there are currently 36 analyses in progress, all at similar level of effort. Twelve of those analyses, exactly one third of them, are in the core physics program. Given that the FTE effort on each exotics analysis is roughly similar, the FTE effort for the core program scales by one third, thus 36 should be reduced to 12, which is very close to the estimate in Table 3.

	CDF		DØ	
ALGORITHMS	**FY07**	**FY09**	**FY07**	**FY09**
Tracking	5.1	3.4	2.9	1.9
Muon Reconstruction	0.5	0.5	2.5	1.0
Calorimetry, Electrons and Photons	2.2	2.2	7.5	2.3
Taus	1.7	0.9	1.4	0.6
Jet Energy Scale	4.8	2.8	6.8	1.2
b-tagging	2.5	1.3	4.0	1.5
Trigger	7.8	4.1	17.4	4.0
Simulation	3.0	2.7	4.0	3.5
Luminosity	0.3	0.2	1.5	0.5
High Level Data Handling	7.5	7.5	6.5	4.5
Infrastructure	0.0	0.0	0.4	0.4
TOTAL ALGORITHMS	35.4	25.6	54.9	21.4
PHYSICS	**FY07**	**FY09**	**FY07**	**FY09**
B_s: Mixing, Rare Decay, Lifetime	16.0	13.0	15.5	11.5
EW: W mass	5.0	5.0	13.5	8.0
Higgs: SM and SUSY	17.0	15.5	17.5	16.0
New Phenomena: Trilepton, Squarks& Gluinos, Stop&Sbottom, LED, Z'	11.5	7.0	9.0	6.0
Top: Mass and Single Top Production	17.5	11.5	16.8	12.0
Core physics management	7.0	5.0	7.0	6.0
Tevatron Combination	3.0	3.0	3.0	3.0
Godpararents / Editorial Boards	4.0	4.0	4.0	4.0
TOTAL PHYSICS	81.0	64.0	86.3	66.5
Yearly Totals	116.4	89.6	141.2	87.9

Table 3: Core physics program algorithm and analyses FTE requirements

In the Top group, approximately 30 of the 80 FTEs currently engaged are working on the top mass, V_{tb}, or algorithms associated with these measurements. As with the Exotics group, the Top group is using about 1/3 of its available effort to perform its core analyses. Thus, the 80 FTEs projected to complete the core analyses in FY07, which is about 1/3 of the current FTE effort engaged in physics analysis, seems to be well matched to the scope of the core program.

In the final year of running, both CDF and DØ require about 90 FTEs to maintain the algorithms and core physics program. In 2007 CDF requires about 116 FTEs while DØ requires 141 FTEs. The majority of the 25 FTE difference can be attributed to algorithmic development associated with the upgrades of the DØ trigger and tracking.

The spreadsheet, of course, does not address some key issues. The analyses in the core program are in many cases quite challenging. They build on work that has already been done or is underway. However, the benefit of that work will only be realized if experienced data analysts continue to be involved in the analysis throughout this period. Another important issue relates to the “service fraction” that each physicist performs. Many scientists are more motivated by final data analysis than by experimental operations. At the beginning of Run II, algorithm work was also viewed as service work. With maturing detectors, this effort is more closely related to physics analysis. In understanding the “service fraction” required of each physicist, it becomes important to understand how to partition, as a function of time, the algorithm development between service work and physics analysis.

5 RESOURCE AVAILABILITY

5.1 TASK FORCE PROCEDURE

In order to understand the resources currently available from the collaboration and expectations for collaboration support between now and 2009, both experiments surveyed the PI's of each US and foreign institution. Each institution was asked to provide the following information:

- Estimated FTE fraction as a function of Fiscal Year individually for each faculty member, research scientist, post doc and graduate student.
- FTE fraction resident at FNAL based on the categories listed above as a function of fiscal year.
- List of institutional responsibilities and FTEs each group would allocate to each responsibility by fiscal year.

To be consistent, we defined the FTE of work dedicated to the experiment to be the fraction of a work week each individual spends on either CDF or DØ. This removes any ambiguity due to teaching loads and University administrative responsibilities.

5.2 RESULTS

We consider separately the period from 2006 and 2007 and the period from 2008 and 2009. The data on personnel availability are much better understood for the first period since they are based on MOUs and are less dependent on external factors such as the actual schedule for the LHC.

5.2.1 Resource Availability for the Period 2006-2007

The resources available to CDF and DØ are based on the MOU process and associated surveys. The results of the surveys are tabulated below. For CDF, 51 institutions out of 57 responded. For DØ, 80 out of 80 institutions have replied. Table 4 indicates the available FTE resources with respect to 2005 separately for CDF and DØ based on the surveys. The survey referred to as “HEPAP” was carried out by a working group of HEPAP chaired by Raymond Brock of Michigan State University and James Whitmore of the NSF. While these surveys were performed independently, the behavior is quite similar. For comparison, the findings of the "HEPAP Survey" are given in the top row. Recall that the HEPAP survey restricted their study to US institutions. The FTE counts available in 2007 are shown in Table 4.

	CDF		DØ	
	2005	**2007**	**2005**	**2007**
HEPAP,US	256	176	237	155
US	267	194	240	170
Foreign	167	125	228	175
US+Foreign	434	319	468	345

Table 4: FTEs available to CDF and DØ in 2005 and 2007

5.2.2 Resource Availability for the Period 2008-2009

It is more challenging to reliably project the resource availability to the period 2008-2009. Many grants will come up for renewal, so the level of support for students and post docs is uncertain. The status of other projects that compete with Run II for resources such as the LHC is also an unknown. The polling of the collaborations about this period produced fewer definitive responses than the MOU process obtained for the period from 2006-2007. CDF found that their data agreed fairly well with that of the HEPAP study. DØ's data was less complete. We decided that the best method to use to get a rough estimate of resources available in 2008-2009 was simply to extrapolate the existing resources using the HEPAP trends. That result is shown in Table 5.

	CDF	DØ
	2009	**2009**
HEPAP,US	105	94
US	116	99
Foreign	75	101
US+Foreign	191	200

Table 5: Rough extrapolated estimate of FTEs available to CDF and DØ in 2009

5.3 SUMMARY AND CAVEATS

Both collaborations performed bottoms up estimates of the scientist and technical resources available from each institution in the collaboration as a function of fiscal year. These numbers, within errors, are the same as those obtained in the "HEPAP" survey, which studied only US resources. This study also includes the resources available from the non-US institutions. We find that their decline is quite similar for foreign and US collaborators throughout this period.

It is worth noting once again that most of the groups in CDF and DØ plan to ramp up their participation in experiments at the LHC during this period. The predicted rate of transition from the Tevatron to the LHC is based on the current LHC schedule and drives the reduction of resources devoted to the Tevatron. It is clear that the actual rate of the transition will depend on how the LHC schedule unfolds; how the Tevatron luminosity develops; and whether any new physics is uncovered at the Tevatron in the next two years.

6 BALANCE BETWEEN RESOURCES AND NEEDS

6.1 PHYSICIST RESOURCES

All of the bottoms up estimates of resources were made with the goal of examining the numbers to see whether the experiments needs are matched to available resources. The nature of the challenge is illustrated in Table 6.

FY05 = 100%	2007	2009
HEPAP, US	69%	41%
US	73%	43%
Foreign	75%	47%

Table 6: Evolution of Physicist Resources for CDF from 2005 to 2007 and 2009.

The collaborations are motivated by physics. Therefore the two questions are whether there are enough people available to complete the core physics program and second, whether the core program is of sufficient size to support the "service work" required to operate the necessary infrastructure. Few physicists will stay involved in collaboration if there is only service work and insufficient time to perform physics analyses of their choice.

We have made an initial attempt to estimate the "gap" between available resources and needs. Since our confidence in the availability of physicists is higher in the early period of 2006-2007 than in the period of 2008-2009, we treat these two periods separately.

6.1.1 Balance between physicist resources and needs in 2006-2007

Table 7 below is a summary of the bottoms up estimates for physicist needs gathered by the subgroups. It breaks out those "service work" tasks that need to be performed for 2007 for each experiment, as well as the requirements for the "core physics" analysis. The needs are "lower" in 2007 than at present mainly because they only cover the core physics program.

	2007	
	CDF	**DØ**
Operations	55	68
Offline	26	32
Algorithms	35	55
Management	10	10
Total Service	126	165
Core Physics	81	86
Core + Service	207	251

Table 7: FTEs required to do service work and the core physics program in 2007.

Table 8 compares the resource needs against the available resources. The physicist resources needed (from Table 7) are given in the first line of Table 8. The resources available (from Table 4) are given in the second line of Table 8. The difference of available and required resources is listed in final line.

	2007	
	CDF	**DØ**
FTE Required	207	251
FTE Projected Available	319	345
Projected Available –Required	+112	+94

Table 8: Comparison of physicist FTEs required, FTEs available, and the balance (available – required) in 2007. The "FTE's required" are calculated assuming no constraints on service effort and an analysis effort only for the core physics program.

6.1.2 Detailed comparision of physicist resources and needs in 2007

The above information implies that there will be adequate total FTE personnel to staff the experiments in 2007. However the FTE totals do not necessarily indicate that the proper expertise will be available for efficient operation of the experiment. To gauge the appropriateness of the labor pool and the degree to which collaborating institutes are committed to providing the necessary personnel for service tasks, DØ has compared the detailed individual information in the draft institutional MOUs with the specific tasks listed in the operations, computing and algorithms estimates.

With respect to operations the comparison shows deficits in five specific areas corresponding to ~ 5 FTEs: controls, online and data acquisition, data quality monitoring, tracking detector operations and management. In the area of algorithms there are five expected shortages in calibrations/databases, tracking algorithms, calorimeter algorithms, detector simulation, and general infrastructure corresponding to ~10 FTEs. Four areas were also identified in computing: SAM-Grid (both for development and deployment), databases, code release and build support, and Linux desktop support. These identified computing areas are consistent with earlier findings, and very constructive discussions have already taken place between CD and DØ. In some cases, concrete efforts are already underway to address these areas of concern.

These detailed comparisons suggest the effort of order 15 additional physicists and 5 computing professionals should be reassigned or identified to continue healthy operation of the experiment in 2007. The comparisons are not too worrisome as there are a number of remedies. For instance, it may be possible to reduce the size of the identified gaps by negotiation with collaborating institutes, by reprogramming of effort out of areas where our "steady state" estimates indicate we may have a surplus of effort, or by asking for increased service contributions. Increased visitor budgets will be essential to ensure the success of such initiatives. In some areas, such as data acquisition, grid technology, databases, and code infrastructure, it is difficult to find the necessary expertise and/or continuity of effort within the collaboration and we hope that the needs can be met by assigning laboratory professionals.

The CDF operations heads have performed a similar analysis, and concluded that the needs of that experiment are best served by an augmentation of the technical support staff, coming primarily from the PPD. The details of the request for an additional ~10 FTE's are in sections 6.2 and 7.1.

6.1.3 Balance between physicist resources and needs in 2008-2009

The resource requirements for 2009 are given in Table 9, subject to the caveats given above. The needs are reduced in 2009 from 2007 (Table 7) because of operational efficiencies due to stable operations, which will result in reductions in trigger and algorithm development.

	2009	
	CDF	**DØ**
Operations	55	68
Offline	20	25
Algorithms	26	21
Management	10	10
Total Service	111	124
Core Physics	64	66
Core + Service	175	190

Table 9: FTEs required for service work and the core physics program in 2009.

The work by the collaborations to determine physicist availability in 2008 and 2009 is necessarily still in progress. However, where we have data, the data agrees well with the HEPAP study. We estimate FTE's available by projecting 2009 FTE's using the HEPAP numbers. The result is shown in Table 10.

	2009	
	CDF	**DØ**
FTE Required	175	190
FTE Projected Available	191	200
Projected Available –Required	+16	+10

Table 10: Comparison of physicist FTEs required, FTEs available, and the balance (available – required) in 2009. The "FTE's required" are calculated assuming no constraints on service effort and an analysis effort only for the core physics program.

6.1.4 Discussion

According to the results enumerated in Tables 7 and 8, CDF and DØ will have enough physicists to support operation and the core analysis through 2007, and will be able to carry out important physics analyses beyond the core. There are some areas in which expertise has not yet been identified but these are few in number and several strategies are available to ameliorate difficulties. It is difficult to estimate reliably the available effort in 2008 and 2009. Our best information indicates a close match between the sums of FTE's required and available, from which one would conclude that there will be shortages in areas requiring specific types of expertise, either in operations or analysis. It is likely that some remedies will be required to support the core physics program after 2007.

This “spreadsheet view” is somewhat at odds with the situation as currently perceived by CDF and DØ leadership. They report that it is already difficult to fill some key jobs. The task force examined and discussed this mismatch in perceptions. There are at least three issues that are not taken into account in the spreadsheets. First, there are many people who are untenured physicists, graduate students and research associates who have temporary positions that expire in the next four years. Many of these young people have already met the service requirements of their collaboration and may be reluctant to accept the burden of service work implied by the spreadsheet; second, many of these students and RAs already are well-advanced in analysis of non-core topics and will not switch to core program analyses at this point; and third, some physicists will choose analysis projects based on their own interests and will work on topics outside the core. Because of these issues, it is possible that the effort on the core program will drop below what is required by 2008 in some areas, unless additional remedies are invoked.

One consistency check for these conclusions is provided by considering the “service fraction” for physicists. Looking at CDF in 2007, we see that total service work is 39% of the total effort if “projected” resources are considered. For DØ, the number is 48%. For the following analysis, we have assumed a service fraction of 50%. Looked at from this perspective, both CDF and DØ will have sufficient physicists to carry out the service work to ensure proper operation of the detector in 2007. CDF will have a comfortable margin of excess FTEs, but DØ will need to carefully monitor the deployment of effort. By 2009, the situation would be difficult for both CDF and DØ. Moreover, many of the physicists who will be active in this period already have met their service requirements as currently defined and are spending a very high fraction of their time on physics analysis whose completion is crucial to their careers. These people may not eagerly accept additional service work. Remedies discussed in section 7 are specifically directed to enlarging the average research fraction. Table 11 demonstrates that nature of this problem very clearly. The balance of needs and available resources using this approach is given in Table 11. Note there is some uncertainty associated with the arbitrary choice of a 50% service fraction.

	2007		**2009**	
	CDF	**DØ**	**CDF**	**DØ**
FTE Required (Service Fraction 50%)	252	330	222	248
FTE Available	319	345	191	200
Available - required	+67	+15	-31	-48

Table 11: Comparison of physicist FTEs required, FTEs available, and the balance (available – required) in 2007. The “FTE’s required” are calculated assuming an average service fraction of 50% and analysis effort only on the core physics program. For 2009, the FTE available is calculated based on expected reduction from the HEPAP survey in 2009 and the experiments projected 2007 FTE effort.

Another issue involves the likelihood that physicists can be induced to support the “core program.” The “core program” is selected to include the topics that are either important to complete before the LHC begins to produce data or that have special relevance to the LHC startup period. Some of the other analyses will be rapidly overwhelmed by early LHC data. This is a powerful argument in favor of the core program. In 2007, there may be enough analysis capability to support a reasonable number of analyses outside the core program However, in 2008 and 2009, there are barely enough people to carry out operations and do part of the core analysis.

A final consideration is the lead-time it takes to implement remedies for missing personnel and expertise. There is a learning curve associated with mastering operations and physics analysis at the collider experiments. While operating conditions and computer codes will stabilize and documentation can, with effort, be improved it may take of order a year for people to come up to speed.

We believe the methodology illustrated by Table 7 through Table 11 reasonably bracket the resource needs and availability faced by the collaborations. Even with implementation of more efficient operations and analysis models, CDF and DØ will need additional expert personnel to keep operating and carry out the core physics program in 2008-2009. Because of the lead-time to implement remedies and the learning curve issues, we expect that the shortfalls predicted in 2008-2009 could be shifted forward into 2007.

6.2 PARTICLE PHYSICS DIVISION RESOURCES

The Particle Physics Division provides scientific, technical and material resources to support the Fermilab experimental and theoretical physics programs. Support of CDF and DØ are among the highest priorities of the lab, and therefore of PPD. Each experiment is directly supported by a dedicated Department of PPD, each consisting of about 35 people, most of whom are physicists or RA's, plus several Computer Professionals and other support staff. Each experiment is also supported by a dedicated crew of technicians and engineers drawn from the PPD Mechanical and Electrical Engineering Departments. Three administrative support personnel are assigned to each experiment. Upgrade and maintenance tasks draw upon additional technical resources from the two Engineering Departments and the Technical Centers Department. Overall, about 28% of the PPD staff is directly involved in the support of the two Collider experiments.

PPD also provides each experiment with a budget on the order of $0.5M per year to support visitors and guest scientists. This provides support for visitors ranging from coverage of some travel or local housing expenses, to full salary coverage for brief or extended stays at Fermilab by collaborators on the two experiments. This support provides a valuable source of personnel for the operation, maintenance and upgrades of the two experiments.

This past spring, the PPD developed a five year staffing plan covering all activities for which it is responsible, including existing and new experiments, R&D programs aimed at future initiatives, lab-wide services, and maintenance and improvement of technical facilities. The overall staffing was assumed to decline at about 4% per year, consistent with a personnel budget that is constant in then-year dollars. The projections for CDF and DØ were developed by their respective department heads, and were based on the assumption that the current operational model would continue through 2009. With this assumption, the staff provided by PPD to each experiment is constant, except for the roll-off as the Run IIb upgrade projects are completed, and a decline in the number of RA's in 2008 and 2009 as terms expire without replacement. In this way the fraction of PPD staff devoted to the Collider experiments is projected to remain approximately the same as the overall staff declines by about 15% over the five year period.

CDF has proposed that about a dozen additional PPD personnel be provided to support operations (see Section 7.1). This would free at least this many physicists (from Fermilab or the collaboration) to perform other service work or physics analysis. These 12 people consist of 7 technicians, 2 engineers or engineering physicists, a computing professional, an RA and a staff scientist. In terms of raw head count, the staffing plan indicates that this many technicians, and probably the others as well, should be available, and that a comparable number, if requested, could be provided to help support DØ as well. However, as has been pointed out in several other places in this report, such a "spreadsheet view" hides the details of the actual skills needed versus those available in the pool of technicians and other technical staff. The next steps will be for CDF to identify more completely the types of skills and abilities that they need, so that we can see whether we can, in fact, satisfy CDF's request. Inevitably, some compromises are likely to be necessary, and shifting technicians and engineers to CDF and DØ will result in the slowing down of other PPD programs, even if the head-count analysis says that personnel are available. Clear decisions on relative priorities will have to be made. DØ has made a detailed comparison between needs and available personnel in 2007 and lists a number of areas requiring addition help. Some of these are well suited to PPD expertise and discussions are underway to identify personnel. The numbers suggested by the CDF operations plan and DØ analyses are similar.

The same staffing study suggest that there are between 5 and 10 more scientists in PPD than are required to carry out the program in FY2006 as planned last spring. However, this apparent surplus disappears in FY2007 as NOvA, ILC R&D, and astrophysics experiments expand. (The number of physicists assigned to CMS is constant in this plan from FY2006 on.) The apparent 2006 surplus is also roughly the number of physicists who transferred into PPD since the staffing plan was made, most of who came from AD with the completion of the NuMI project with the intent to pursue neutrino physics. We are currently revisiting the physicist portion of the staffing plan to understand better the intentions and commitments of all PPD scientists; with an eye to determining how best to support the Collider experiments, while still supporting other important parts of the Fermilab program and preserving some degree of "academic freedom" for Fermilab scientists.

6.3 COMPUTING DIVISION RESOURCES

The Computing Division provides computing services and scientific effort and leadership to the Run II collider experiments. Support of CDF and DØ are among the highest priorities of the lab, and therefore of the Computing Division. The Division effort (about 260 FTEs) is predominantly organized in three large departments that provide central services: Computation and Communication Fabric (CCF), Core Support and Services (CSS), and Computing and Engineering for Physics Analysis (CEPA). Experiment and R&D enterprises access these services through satellite departments in the Division. These departments are "the Running Experiments" department (REX), CMS (CMS), Experimental Astrophysics (EAG) and Accelerator Modeling and R&D (AMR).

The Run II experiments access central services through the Running Experiments department (REX), which is led by DØ and CDF scientists. The REX department is composed of about 35 FTEs organized in the following groups: Data Handling and Databases, CDF&DØ Offline Support, Data Production, System Administration, Project Leads, and MINOS support. The REX department coordinates the Run II Computing Division effort summarized in Table 2.

Each Run II experiment receives an annual Material and Services budget (M&S) of about $1.5M from the Division. The planning and allocation of this budget is the responsibility of the REX department. The budget plan and effort deployment is annually reviewed by an external panel of experiment and computing experts: http://cdinternal.fnal.gov/CDEvents.asp#RUNII

The Division is organized in "matrixed" central services to meet the growing demand for computing in the face of diminishing resources. Delivering solutions based on common commodity hardware (e.g. Mass Storage, Networking and Linux compute farms) and common distributed computing models (e.g. SAM-GRID and other grid technologies) are the principal strategies to meet the needs of the Run II science program. This overall strategy has proven successful and has allowed resources and effort to be effectively leveraged across the Division.

The Computing Division resources projected to be available to the Run II experiments will be adequate to meet the projected needs summarized in Table 2. A risk analysis to meeting this need is summarized in section 3 of this document. Section 7 of this document presents "Remedies" which can be considered as a source of contingency that largely mitigates the risks outlined in section 3. Continued movement toward common services and grid computing to exploit world-wide resources are key in mitigating risk and realizing the resources required throughout the computing phase of the Run II science program.

7 REMEDIES

In this section, we suggest possible remedies for personnel shortfalls assessed and described in the previous sections. We outline a plan that will ensure successful operation, data processing, and analysis of data taken through the 2007 running period. A short discussion follows of possible additional steps that could be taken in the later years of the program. There are many parallels between the two experiments in scale and composition, as illustrated in the previous sections. Accordingly, many remedies identified here are common. Any differences in the preferred solutions between the two collaborations will be called out.

7.1 DETECTOR OPERATIONS AND MAINTENANCE

We begin with recommendations for detector operations. The basic strategies are to broaden the personnel pool to compensate for the anticipated losses from the existing collaborations and to decrease the overall numbers required to operate and maintain the detector. Some combination of these two strategies will be required.

The pool of appropriate individuals can be maintained and broadened by encouraging involvement of additional institutions. The supply of experts and shifters could also be maintained through continued direct support of these collaborating institutions by the various funding agencies. Demand will be reduced by further concentrating responsibilities, improving efficiency, or perhaps reducing or compromising scope. Concentrating responsibilities is an option that has already proved fruitful when applied to the shifters.

There are several ways to improve efficiency that will reduce the level of expert participation required. For instance, reductions in turn-over of experts would reduce the time spent training new experts, and likely also improve performance. This could be accomplished by transferring more of the expert responsibilities to permanent laboratory staff. Likewise, if the duty factor of individual shifters was increased, shifter efficiency would improve. Automation to monitor and detect problems has already been implemented throughout detector operations, and additional implementation should be encouraged. For example, both detector groups are working on additional automation of data quality assessment. As failure modes are observed and diagnosed, attempts are made to address the root causes when possible, such efforts help maintain efficiency in the face of aging detectors and increasing luminosities.

On the supply side, the two experiments have somewhat different expertise needs, so the proposed solutions are also somewhat different. At CDF, two of the control room shift personnel are responsible for operating the DAQ system and for monitoring and controlling the detector voltages and accelerator conditions. CDF has proposed replacing one of these people, the "monitoring Ace", with a professional shift crew composed of laboratory technicians. CDF has studied this proposal in some detail and has determined that efficiency improves with more highly trained and focused staff on shift. The staff will be trained to handle many problems that are not now within the capabilities of the physicist monitors. The added versatility will enable physicists to focus on analysis and lower the burden on on-call experts who carry pagers. This improvement will result in a reduction of more than 5 FTEs of physicist labor.

For DØ, with development of appropriate tools and documentation and cross-training of shifters in various areas of responsibilities, it will be possible to consider significant reductions in the control room crew size without substantial reduction in detector performance. Such merging of shift responsibilities has been effective in the past. DØ is anticipating that after the Layer 0 silicon detector and the AFE II fiber tracker readout boards are commissioned it should certainly be possible to combine the responsibilities of the two shifters currently monitoring the Silicon Microstrip Tracker and the Central Fiber Tracker into a single Tracking Shifter. It may also eventually be possible to combine the Tracking Shifter's responsibilities with those of the Calorimeter and Muon Shifter, resulting in a single Detector Shifter. During crucial moments in the control room (such as at the start of store), it might be necessary to redirect the Operations Shifter to the control room to maintain performance with this reduced crew. Such changes could result in a reduction by 10 full time equivalents in shifter demand.

For both experiments, there are also operational efficiencies available by encouraging involvement of additional institutions through modest additional lab support for visitors. This funding would encourage collaborators to come to the lab for extended stays. Support for new visitors for several months could be used to enhance the pool of shifters, and longer stays might encourage such visitors to serve as experts. Support for existing collaborators who are experts and are transitioning to the LHC would be used to document and improve the systems. This would reduce the operational personnel and training required, while also augmenting the LPC efforts.

In addition, there are large foreign contingents on both experiments for whom the end effects of travel to the US are significant, especially for a one week stay. CDF is working to develop the capability to have one on-site shifter replaced by people at remote sites. This is challenging, but we are working with the US CMS people who are developing the same capability. If successful, this would be a valuable savings of a couple of travel days per shift, which is not included in any of our calculations, might make foreign collaborators more willing to continue participation in the collaboration, and would reduce the "owl" shift burden on local people.

In summary, we anticipate that CDF could reduce the physicist shift load by 8 FTEs by shift and online reassignments of tasks performed by physicists. DØ could reduce the physicist shift load by 10 FTEs if the various detector monitoring shift duties are merged to one detector shifter. Additional support for visitors could reduce the burden on the current set of experts and shifters. Assignment of additional lab staff to operations would improve efficiency and reduce the time experts devote to training new experts. We have not attempted to estimate the potential impact of additional operating efficiencies upon the FTE load as such gains may well be offset by as yet unidentified challenges due to detector aging.

7.2 COMPUTING AND DATA PROCESSING

Event processing and computing becomes increasingly difficult as datasets grow through the life of an experiment. Consequently, the Run II experiments will require access to expanding computing resources as well as limited developer effort well into the late stages of the experiment. Grid resources will play a central role in addressing this need. To ensure sufficient personnel for the experiments, the Computing Division will direct parallel efforts within the Run II experiments to adopt common solutions, to move key infrastructure into centrally supported services, and to leverage the large and increasing personnel devoted to LHC grid technologies. The committee supports these goals as one effective means to reduce the long-term operational effort required by the experiments, and recommends that Fermilab fund the direct efforts to achieve them even at the expense of increasing Run II personnel in the short term.

Successfully leveraging the LHC grid technologies and resources is particularly important because they are essential for the success of the Run II experiments. The existing LHC grid functionality forms a strong foundation upon which to build the Run II grid infrastructure at the lowest cost in terms of additional personnel.

The committee further recommends the following steps to improve operational efficiency and mitigate risks in the support of key technologies and infrastructure.

- Grid deployment team: The Computing Division should form a grid deployment team charged with the responsibility to assist remote sites deploy the products required by the experiments to better exploit a grid-based computing model. The additional personnel will allow the existing developer base to focus on such tasks as creating viable grid-based analysis models for the Run II experiments.

- Interoperability: Fermilab should aggressively pursue the implementation of interoperable solutions for distributed computing by the Run II experiments. The first goal should be to make SAM grid fully interoperable on OSG and LCG computing resources. Funding for these projects should be sufficient to ensure success in a timely manner.

- Consolidation of key central services: The Computing Division should attempt to consolidate critical functions that can be performed by computing professionals under the umbrella of the central services model. For example, there are likely some gains in operational efficiency in addition to a reduction of risk in the support of DØ code management and the build and distribution systems to be obtained by cross-training with the equivalent CDF personnel. Drawing more of the experiment-specific database support into the Computing Division may reduce the risk of losing effort for these tasks as the collaborating institutions devote more of their resources toward the LHC experiments. Transferring system administration responsibilities for the Level 3 trigger farms to the Computing Division could stabilize a fraction of the operational load for these systems. This task is a reasonable match to existing farm administration responsibilities held by the CD.

- CD guest scientists: Fermilab should expand the Guest Scientist program within the Computing Division. Guest Scientists take on critical managerial and technical roles within the experiments. For example, scientists within these posts may very naturally sit between core grid developers and the users as the experiments further exploit grid computing models. Using the Guest Scientist program as a tool to attract excellent physicists not only effectively broadens the pool of available candidates to staff such positions, but also helps to change the perception that computing jobs should be avoided by high-caliber physicists.

- Associate Scientist and Research Associate positions: The lab should fund additional Associate Scientist and Research Associate positions within the Computing Division. These individuals fill critical computing roles within the experiments, strengthen the scientific program of the lab, provide mentors and role-models to attract young physicists to computing and augment other attempts to change the perception that a computing specialization is contrary to a strong physics orientation. These individuals might be targeted to the tasks currently considered to be sources of risk because a single person covers them.

In the short term, we estimate the above recommendations to add about three to four computing professionals and a comparable number of scientific staff members to Run II computing. The needs will fall as projects transition into a maintenance phase. A modest reduction in the net personnel requirements should follow from consolidating key central services. Note that addressing some scaling issues may require a temporary but significant influx of personnel beyond the values presented.

7.3 CORE PHYSICS PROGRAM

The efficient and timely production of physics results is critical to the success of the Tevatron program. While there was little external competition in 2001, the LHC startup is now much closer, and Run II results published long after LHC startup will be of limited interest. An important mission of the Tevatron program is the training and education of scientists. Rapid analysis of data and production of results will benefit these students. The analysis subgroup limited its discussions to the definition of a "core" physics program and the determination of the minimum personnel needed to produce the corresponding results. It is possible to go further, and to investigate possible improvements in the analyses that would reduce the number of FTE's required for each result. Understanding, proposing, and implementing those types of improvements is something that requires a broad collaborative effort and consensus, and there was not time in this group to undertake that. However, we have several proposals to ensure adequate personnel resources to execute the core physics program. The proposals are:

- Increased support for students from developing countries and existing CDF/DØ institutions
- Additional Fermilab postdocs. These positions could provide postdocs with the possibility to share time between CMS and CDF/DØ.
- Support for senior physicists in the form of sabbatical for professors or senior researchers, especially from developing countries
- Encouragement for Fermilab scientists' non-research fraction to go to CDF or DØ algorithm work
- Additional Computing Specialists for data handling help

The scale of resources required are developed in the previous sections. There are uncertainties because the people that will be brought in the do "service work" on issues like algorithms will also be doing analysis part of the time, the actual line between service/algorithm work and analysis work, especially the study of systematic effects, will shift and blur as the experiments and the analyses mature, and the estimates required to accomplish the analyses are themselves uncertain. Taken together with the analysis contributions of the physicists brought on board to do service work, these proposals will strengthen the program through 2007 and provide the lead time to fill the "gap" in 2008 and beyond. Aggressive use of these programs, which is certainly possible given modest size of the needs, may be necessary to fill the shortfall in 2008 and 2009.

These are only a few suggestions. Fermilab and the collaborations should move aggressively over the next few months to define and implement programs to achieve these goals. The programs should be started in 2006 and attain their full strength in early 2007. They should continue until at least the end of 2009. We recommend that in early 2008, the personnel resources for the analysis effort be re-examined in light of the status of the analysis effort, the luminosity, and the interest in the physics that is emerging. At that point, these programs could be enlarged if necessary to get the highest impact physics out in a timely manner.

7.4 SUMMARY OF RESOURCE REMEDIES

If the efficiency savings and the personnel increases discussed in the above three sections are successfully implemented, we conclude that operations can be successfully staffed through 2009 and the shortfall in physics personnel for analysis anticipated in 2008 and 2009 can be remedied. For these programs to be successful, the physicists who join must have time to master the analysis techniques. The programs should therefore begin well in advance of 2008 when the shortage is otherwise expected to become serious.

8 CONCLUSIONS AND RECOMMENDATIONS

This task force has established a common method for tabulating the needs of the two collaborations. We have provided a detailed bottoms up estimate for operations of both the detector and offline analysis and have discussed the limitations of these estimates. Both experiments reviewed their available scientific resources from now through 2007, and with more limited precision in 2008 and 2009. These estimates were based upon updating the MOU's between the collaboration and the experiment as well as well as a survey of the PI's from each institution. Finally, to understand whether there are sufficient physics analysis resources, the collaborations agreed upon a core set of physics analyses which are scientifically compelling and establish much of the foundation for other analyses. Based upon this core set, each collaboration estimated the resources required to develop and maintain the algorithms and complete those physics analyses. The provides a lower limit on the analysis effort required.

8.1 MAIN FINDINGS OF THE TASK FORCE

- The number of physicist FTEs available to each experiment is expected to decline from 2005 levels by approximately 27% by 2007 and 56% by 2009. We find that the HEPAP personnel survey and the MOU surveys carried out by the experiments agree well in 2005 and 2007. For CDF, the current estimates for operations agree well with HEPAP estimates. However for CDF, the current best estimates for physics analysis are lower than that reported in HEPAP due to a difference in the scope of the physics program that is delivered. For DØ, it is the reverse. The DØ estimates for the effort needed to deliver the operational program are substantially lower than those reported to the HEPAP survey, whereas the effort devoted to physics analyses is consistent with HEPAP.
- In 2007 we find an approximate balance between needs and availability, even when the needs for a physics program considerably broader than the core program are considered. Because of the greater degree of development still expected in 2007 for DØ than CDF, a greater degree of care will be required in achieving a healthy balance between needs and availability for DØ.
- There is also general balance in terms of expertise. However there are a relatively few areas in which there is insufficient personnel. Some of these areas lend themselves to redeployment of individual effort and others will require identification of personnel with select skills within Fermilab and institutions.
- We have identified a number of areas where Fermilab PPD and CD effort should be used to increase productivity and efficiency of the experiments. They will require modest additional resources from the laboratory in terms of staff and visitor support. Both the Computing Division and the Particle Physics Division have presented their currently expected budgets and staffing levels; they expect to be able to at least maintain support at their current levels.

Our overall conclusion is that through 2007, the collaborations will run effectively and accomplish at least the core physics program. The collaborations are planning for a physics program much more extensive than the core program and are working to ensure they have the necessary resources to carry this out in 2007. Predictions in 2008 and 2009 are less certain; they depend on larger issues such as the schedule for the LHC, the evolution of Tevatron luminosity, and the physics emerging from the first 2 fb^{-1} of Run II. Nevertheless, for the experiments to operate efficiently and complete the core physics program in 2009, remedies beyond those proposed in Section 7 will probably need to be implemented.

We conclude this document with recommendations of specific actions that the Fermilab Directorate and the external agencies should consider to ensure the success of Tevatron Run II. While this report concludes that there is likely to be sufficient person power to complete the Tevatron program through 2007 and beyond, we believe these recommendations, once implemented, will reduce or eliminate risks to the program in later years that may arise from unexpected shortfalls in critical areas.

8.2 RECOMMENDATIONS FOR THE DIRECTORATE CONCERNING FERMILAB RESOURCES

The collaborations, the Particle Physics Division, the Computing Division and Fermilab will need to continue to work together very closely to ensure the success of the Tevatron. The following are recommendations to the Fermilab Director concerning actions he can take within the laboratory to achieve his goal:

1) Require the divisions to update the laboratory staff profile needed to fulfill Fermilab responsibilities to complete the Tevatron program. *The profile should be used by the division heads to develop a sustainable staffing plan, especially for the scientific effort, with attention paid to an efficient labor succession plan that insures that adequate resources remain in place over time to fulfill Fermilab commitments.*
2) Communicate the laboratory staff plan for the Tevatron and LHC to Fermilab staff scientists engaged in the Tevatron collider program. *Assurances that CMS membership opportunities will remain open at later dates will prolong and enhance interest in and the attractiveness support of the Tevatron program and add clarity to staff expectations.*
3) Encourage the experiments and divisions to continue developing efficiencies that reduce the effective labor required to operate the Run II programs. *Examples include grid computing initiatives and cross training of operational staff.*
4) Continue to promote the Tevatron program to incoming Research Associates, and, starting in FY06, increase the number of CDF and DØ RA positions by two each. *Attracting the best RA's will be most straightforward now, when physics potential is high and still unique. New additions will ensure that each experiment retains 6-8 RA's through FY08-09 as agreed to by the Associate Director for Research. Realistically these RA positions will timeshare with CMS, ILC, and other future projects; however as sources of experience and technical knowledge these individuals will be of crucial importance to the Tevatron program. In some sense, their involvement in future projects will leverage continued involvement in the Tevatron.*
5) Periodically review with the collaboration spokespeople the degree to which institutional MOU commitments are honored. *The goals of these sessions would be to identify shortfalls in those efforts and, should those shortfalls present problems for the program, to communicate them to the funding agencies. .*
6) Provide strong support for the LHC Physics Center (LPC) at Fermilab and for Fermilab's US CMS hosting activities. In addition, we recommend expansion of the LPC to include limited support for members of ATLAS working on Run II. *This may ensure that physicists working on CDF or D0, who intend to work on CMS or ATLAS, meet their commitments to Run II while ramping up their efforts on their LHC experiment.*
7) Pursue discussions with the International Finance Committee (IFC) from both collaborations to secure and understand their commitments to the program through 2009

8.3 RECOMMENDATIONS FOR THE DIRECTORATE TO EXPLORE WITH THE AGENCIES

Some of the remedies we have proposed will require additional resources at a time when the laboratory budget is shrinking in real buying power. We summarize these in this section. We encourage the Director to explore these recommendations with the funding agencies in the hope that they will make additional resources available to Fermilab to help implement them.

1) Increase visitor budgets for outside personnel by approximately a factor of two. *Visitors have proven to be efficient, enthusiastic, and cost efficient for the performance of many tasks. A predictable visitor's budget also provides an opportunity to ensure important technical continuity.*
2) In concert with the collaboration spokespeople, conduct negotiations with NSF, DOE, and foreign funding sources aimed at retaining or enhancing support for University resources in the areas of greatest risk. *Review with the collaboration spokespeople their assessment of the most critical areas in which MOU service commitments fall below the estimated needs.*
3) Discuss jointly with LHC and Tevatron experimental leadership the difficulties faced by groups and individuals active in both programs. These groups frequently find it difficult to fully contribute to two

programs through the Tevatron-LHC transition period. *Both programs benefit from data-seasoned and experienced students and post docs. Some groups are just below critical mass to fully qualify for membership in two experiments, forcing a choice between the two programs. A negotiated, cooperative, public arrangement among all parties would be valuable to both programs during this transition period. For example, an institution could perform service work on an ongoing experiment with a guarantee of membership on a future experiment at an appropriate later date.*

4) Explore the possibility of contributions from the funding agencies for the creation of **Tevatron Fellowships** to support named university students (5-10 per experiment). *The financial details for the fellowships could take many different forms, from sole NSF and DOE support to leveraged, joint support from all of the relevant groups. Existing programs which attach the award to the awardee and not to the university might serve as models for discussion; current examples here would be the NSF Graduate Fellowships and Hubble Fellowships. Shared fellowships with foreign institutions might also be a possibility.*
5) Similarly, explore the possibility of support from the funding agencies for the creation of **Hadron Collider Fellowships** to support post-docs (3-6 per experiment) resident at Fermilab. The three or four-year fellowships might initially focus on the Tevatron program with a transition to LHC occurring late in the second or early in the third year of the Fellowship. *As with the RA's discussed in recommendation four of the previous group of recommendations, although these fellowships will move towards the LHC, their experience and technical knowledge will be of crucial importance to the Tevatron program. In order to ensure this is an attractive program, a model might be the highly prestigious Hubble Fellowships for astronomy post docs, which are awarded to the candidate, who can then carry it to his/her institution of choice.*

8.4 FINAL COMMENTS

The CDF and DO collaborations, Fermilab, and the DOE and NSF have invested substantial resources in Tevatron Run II starting as far back as the early 1990's. With the exciting recent increases in the luminosity, the improved understanding of the accelerator complex, and the excellent performance of the upgraded experiments, the goals of Run II are now within reach. Even though some collaborators will leave for other programs, especially at the LHC, there should be adequate personnel to take data and carry out the most important analyses, those for which the run was undertaken, through 2007 and beyond. Management attention and some modest additional resources will be necessary to ensure success, especially after 2007. The task force urges Fermilab and the funding agencies to commit the necessary attention and resources to complete this promising program.

APPENDIX 1: CHARGE AND MEMBERSHIP

Preamble

Over the course of the past year, there has been a steadily growing concern about the scientific and technical effort dedicated to the Tevatron Collider experiments. The erosion in the Tevatron effort may have several causes but certainly includes the need for the experimental community to pay increasing attention to the imminent completion of the LHC.

The concern applies to all aspects of CDF and DØ: the actual operations of the detectors, the data production phases and the physics analysis phases. Although for operations and data crunching the needs can be relatively well quantified, that is presumably less easy for the physics analysis phase. It is, nevertheless important to attempt to have as complete a picture as possible of all scientific and technical needs.

Charge

The committee should review what is known about the scientific and technical needs for completing the Tevatron program through 2009. While the committee can choose its own methodology, it would be appropriate to parse the total demands into segments, making some attempt to partition easily understood segments from the more difficult. The task force should make use of existing data from the HEPAP study, from the effort within the experiments to quantify needs, and from the personnel requests the Fermilab Divisions are receiving. The needs should be scrubbed to ensure that they are real, important, and appropriately sized. Reports thus far suggest that the impacts of reduced effort become marked from the start of FY07. It may be difficult to address the full period 2006-2009; in that case the committee should address the needs through FY2007 as an initial step.

As the gap between actual needs and available resources becomes clear, the committee should move to develop a suite of potential remedies. These might include: streamlining of operations and data analysis, sharpening the physics focus and ensuring the essential analyses are being addressed, merging certain support activities for DØ and CDF, increasing the use of post docs and visitors, and making special arrangements with CMS and ATLAS to smooth out the transition from CDF and DØ to CMS and ATLAS. They might include an analysis and recommendations on what the agencies might do to ameliorate the problems associated with the transition.

We would like to hear an interim report from the committee by September 7 prior to the P5 Meeting at Fermilab on September 12, 13.

Committee Membership/Participation: Franco Bedeschi, Gerald Blazey, Amber Boehnlein, Raymond Brock, Volker Buescher, Joel Butler, Gavin Davies, George Ginther, Beate Heinemann, John Hobbs, Young-kee Kim, Ashutosh Kotwal, Michael Lindgren, Pierre Petroff, Luciano Ristori, Rob Roser, Willis Sakumoto, Rick Snider, James Strait, Linda Stutte, Robert Tschirhart, Victoria White, Terry Wyatt

APPENDIX 2: SUBGROUP DEFINITIONS AND MEMBERSHIP

Subgroup #1: Collaboration resources

Task: To reexamine the available resources and personnel numbers for detector, offline operations in the resources survey (HEPAP resources task force) and current MOUs with clarification of how the numbers are counted. This group will also perform the "gap analysis" -- pulling together numbers from all of the other subgroups and determine how well the available resources are aligned to the needs.

Membership: Terry Wyatt and Rob Roser (co-chairs), Luciano Ristori, Pierre Petroff, Young-kee Kim, Jerry Blazey, and Chip Brock.

Subgroup #2: Operations Requirements and resources

Task: To assess needs for detector operations and suggest strategies for more efficient operations - this includes how additional scientific and technical support from the lab can make a difference.

Membership: Willis Sakumoto and George Ginther (co-chairs), Linda Stutte, Mike Lindgren, Rob Roser, Jerry Blazey, Joel Butler, Jim Strait

Subgroup #3: Data Processing requirements and resources

Task: To assess needs for offline operations and suggest strategies for more efficient operations - this includes how additional scientific and technical support from the lab can make difference.
Membership: Ashutosh Kotwal and Gavin Davies (co-chairs), Amber Boehnlein, Rick Snider, Young-Kee Kim, Terry Wyatt, Bob Tschirhart, Vicky White

Subgroup #4: Physics Analysis requirements and issues

Task: To determine the number of FTE's needed for a "core physics" program in the coming years and suggest methods to ensure adequate personnel

Membership: Jerry Blazey and Young-Kee Kim (co-chairs), John Hobbs, Volker Buesher, Franco Bedeschi, Rob Roser, and Beate Heinemann.

To complete the picture, the Computing Division and Particle Physics Division discussed resource availability in their divisions in the plenary sessions.